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LV.—*On the Structure and Habits of* Anthophysa Müllcri, *Bory, one of the Sedentary Monadiform Protozoa.* By H. James-Clark, A.B., B.S.*

During the last five years, and more especially within the latter eighteen months, I have been engaged largely upon an investigation of the relations of the monadiform animalcules to the zoospores of the true *Algæ*; and of all the numerous instances of the former that I have more or less thoroughly studied I have never met with one which could be said to bear but very moderate resemblance to the latter: I refer to the true *Algæ*; I scarcely need add that I mean by this to except those doubtful forms which seem to be related to *Volvox* and *Gonium*, such as *Pandorina, Protococcus, Stephanosphæra, Chlamidococcus*, &c.

Those who have become accustomed to these creatures, and have learned to look upon them, through long years of patient study, as old and familiar friends, know well the value of using the best lenses that the opticians of the present day can afford, and never doubt for a moment the utter worthlessness of an opinion which is founded upon a few fitful glances through a so-called ordinary working microscope. There is no other group of animals which so essentially seems to need the prolonged devotion of a specialist as the Protozoa—and above all, the lower members of that grand division. To write a monograph upon any single one of these flagellate forms may seem like devoting a volume to the structure and phases of a dot in a sunbeam; but no good microscopist need be told that the optical instruments of the present day are no less efficient than was the scalpel in the hand of Cuvier when he displayed to the world the organization of the larger and more elevated animals which he found on the southern shores of France.

Moreover it is particularly desirable that elaborate investigations should be made, and unstinted minutiæ set forth in illus-

* From Silliman's American Journal for September, 1866.

trations and descriptions, because there are yet among zoologists those who suppose that there is so little in the organization of Protozoa that no tangible characters can be found by which they may be typified or assimilated in a group by themselves.

The taxonomic relations of the organs of the INFUSORIA FLAGELLATA have received so little attention from investigators, that there is no small difficulty, with our present knowledge of them, in tracing the typical plan which is so eminently exemplified among the CILIATA. I hope I shall be pardoned, therefore, if I attempt to give a strict topographical view of the positions of the various organs of one among the most lowly of the whole group of animalcules.

A considerable portion of the second volume of the great work of Messrs. Claparède and Lachmann, 'Etudes sur les Infusoires,' &c., is occupied by a discussion of the animality of certain doubtful forms of Monad-like Infusoria. The tests which these authors offer as determinatives of the zoological relations of the forms in question are, the possession by them of a contractile vesicle, and the introception of food. By means of either the one or the other of these criteria they succeed in satisfying themselves that the *Volvocina*, *Astasiæ* (*Euglenæ* included), and the *Dinobrya* are true animals; but in regard to other forms they are unable to decide. Among those which are left in the latter category, there is a singular infusorian which, as is usually supposed, was originally named *Epistylis vegetans* by Ehrenberg, and *Anthophysa Mülleri* by Bory de St. Vincent. Dujardin gives a scarcely recognizable figure of it in the atlas of his work on Infusoria, but very properly places it among the monadiform animalcules. This is done, however, upon its general resemblance to the latter (alike undetermined at that date as to their animal nature), and not because he had by direct observation decided it to be a genuine animal. The figures of Cohn ('Mikroskopische Algen und Pilze,' Nov. Acta Acad. Cæs. Leop. 1854, taf. xv. figs. 1–8) are not much better than those of Dujardin.

Habitat and general appearance.—I have been so fortunate as to determine the animality of *Anthophysa* by both of the tests above mentioned; and there rests not the least doubt in my mind that this infusorian is as truly a member of the zoological kingdom as any of the well-known Protozoa. I would state, for the information of those who are not acquainted with the habits of this animalcule, that it is quite common among the freshwater weeds. It may be most advantageously studied when it is attached to *Myriophyllum* or *Ceratophyllum*—a small piece of the tip of the filiform leaf of either (which seems to be covered by an irregular floccose deposit) usually affording abundant specimens.

Under a low magnifying-power this floccose matter appears to consist of clusters of very jagged, irregularly branching and contorted, semitransparent, intertwined stems, and projecting tapering and flexible twigs. Each of the tips of the latter sustains a single more or less globose mass of spindle-shaped bodies, which radiate from a common centre of attachment, and are kept in a constant agitation by the spasmodic jerks of a long, stout, usually rigid, arcuate filament, with which the free end of each one is endowed. The whole bristling mass revolves alternately from right to left and from left to right, whirling upon its slender pivot with such a degree of freedom that one might almost suspect that it merely rested upon it and had no truer adhesion to it than the juggler's top to the end of the *bâton* upon which it spins. The largest of these twirling groups contains as many as fifty fusiform bodies; but most frequently not more than half that number are grouped together, and from this they vary in decreasing quantities down to only one or two upon each filamentous twig. In the last instances the bodies are comparatively quiet, scarcely moving out of focus at each spasmodic twitch of the arcuate filament. On this account, and because they offer an unobstructed view, the latter are by far the most available as objects for the investigation of their internal organization.

The relationship of the individual monads to the whole colony must, however, be studied where they are more numerously congregated, since, as will be shown presently, each monad sustains a definite relation to every other one, and to the twig to which it is attached. The larger colonies are frequently to be found swimming freely, with a rolling motion similar to that with which *Volvox* progresses. As a natural concomitant to this fact, twigs are to be met with here and there which do not bear anything at their tips. The colonies seem to break away very easily; and on this account the specimens should not be lifted out of the water when transferring them to the watch-glass or whatever sort of observing-trough is used.

Form, &c.—The adult monads have a truncate fusiform shape, and are slightly but quite appreciably flattened on two opposite sides, so that in an end view they appear to be broadly oval transversely. The attached end tapers gradually to a point; and on this account it is difficult to determine where the body ends and the twig begins. All of the members of a group radiate from a common point of attachment, to which they adhere by their tapering filamentous ends. The free end is truncate; but one corner of it, as if in continuation of the line along which the opposite flattened sides meet, projects in the form of a rather blunt triangular beak. At the inner edge of the base of

this beak lies the mouth, to which the former (as frequent observation has proved) acts as a lip or prehensile organ when food is taken into the body. The prevailing tint is a more or less uniform light gamboge, without the least trace of an eye-spot of any colour.

A most singular uniformity prevails in the arrangement of the several members of a group. Each monad is attached to its mooring in such a position that its flattened sides lie parallelwise with those of its nearest neighbour; and the beak projects from that corner of the head which is most distant from the twig. To give a full idea of the peculiarity of this arrangement, it must be stated here that the rigid, arcuate, spasmodically twitching filament mentioned above is attached close to the mouth, and invariably curves away from the beak, and consequently always toward the pedicel of the colony. One is forcibly reminded by this of the systematic relation of some of the flowers of *Labiatæ*, with their stamens projecting far beyond the upper lip of the corolla. The globose heads of the *Menthæ* are particularly good examples for illustrating this similitude.

Prehensile organs.—The only motile organs which this animalcule possesses are preeminently prehensile in character; and their apparent appropriation to the office of propulsion, when a colony breaks loose from its attachment, I can scarcely doubt is an accidental one, inasmuch as the arcuate cilium continues its spasmodic twitching without any apparent deviation from its usual mode of action.

There are two cilia, of very unequal size, attached to the truncate end of the body. The larger one of these has already been mentioned casually, as a *rigid, arcuate filament*. It does not taper, but has a uniform thickness from base to tip, and is about half as long again as the body. It arises near the base of the triangular beak, but appears to be separated from the latter by the intervening mouth. When quiet it appears like a bristle, and projects in a line with the longer axis of the body—at the base bending slightly toward the beak, and then sweeping off in a moderate but distinct curve in the opposite direction, so that on the whole it presents a long drawn-out sigmoid flexure. The plane of this curve lies in strict parallelism with the plane of the greater diameter of the body; in fact it may be said to be a direct continuation of it. It does not appear to have the character of a *flagellum*, except when assisting the smaller cilium to convey the food to the mouth; and then it lays aside its rigid deportment and assumes all the flexibility and wavy vibration of the prehensile organ of an *Astasia*.

The smaller cilium is an excessively faint body, and almost defies the detective powers of the highest objectives. This is

partly due to its almost incessant activity; for when it is quiet, or nearly so (which happens when food is passing into the mouth), it becomes comparatively quite conspicuous under a one-eighth-of-an-inch objective. It is scarcely as long as the greater diameter of the truncate end of the body. It arises close to the base of the larger cilium; but whether on the right or left, or nearer or more distant from the mouth than the latter, cannot be said positively. Most frequently it was observed to be flexed in the same direction as its companion; and occasionally it seemed to be quite evident that it was attached nearer to the mouth than the latter. It is highly flexible, and vibrates with great rapidity in what appears to be a gyratory manner.

The mouth.—This organ is never visible except when food is passing through it. It then may be seen that it lies close to the beak, which acts as a sort of lip by curving over the introcepted particles as they pass into the body. The mouth is highly distensible, at times allowing particles as wide as two-thirds the greater diameter of the body to pass in without any apparent extra effort. It seems undeniable that it possesses discriminative powers in regard to the quality of its food. This one may readily judge of for himself, by seeing the unerring precision with which the particles of floating matter are thrown, by the spasmodic incurvature of the larger flagellum, against the mouth, where, if they are not swallowed, they are detained but for an instant by the smaller cilium, quickly adjudged to be worthless, and then thrown off with a twirl of the organ which held them in temporary abeyance. If, however, the captured morsel prove to be agreeable, the larger cilium assists the operations of the smaller one and the lip, by abruptly bending itself at its point of attachment and laying its basal part across the food and pressing it into the mouth, while the terminal portion is kept in a constant wavy vibration, and curved toward the posterior end of the body. This is usually done in three or four seconds; and then the cilia return to their usual positions, while the introcepted edible passes toward the centre of the body, and is there immediately enclosed in a digestive vacuole. For a while the food dances about in this vacuole with a very lively motion, but finally it subsides into quietude.

The contractile vesicle.—There is a twofold difficulty in discovering the presence of this organ. In the first place, it is comparatively quite small; and secondly, it pulsates so slowly that it is very rarely possible to see it contract twice in succession between any two of the abrupt lateral deviations of the body which the spasmodic twitching of the arcuate flagellum produces. On this account it has not been possible to determine the precise rate of its systole and diastole. It seems to contract

from three to four times a minute. It lies near the surface, about halfway between the two ends of the body, and nearly midway betwixt the two extremes of its greater diameter. At the completion of its *diastole* it has a circular outline, and appears like a clear colourless vesicle in the midst of the yellowish tissue of the body. Upon contraction it disappears and leaves no trace of its presence. The *systole* progresses slowly, as in *Anisonema* (*A. sulcata*, Duj.?, and *A.* nov. sp.), *Cyclidium* (*C.* nov. sp.), and *Phacus pleuronectes*, Duj., and in this respect contrasts strongly with the same process in *Heteromita fusiformis*, Jas.-Clk., *Astasia tricophora*, Clap., and *Cryptomonas* (*C.* nov. sp.), in which the last half of the systole is very abrupt and marked.

The stem.—In addition to what has already been said of the general appearance of this part of the organism, it may be added that the older and basal portions of the branches are flat, and have a distinct longitudinal irregular striation, to all appearance made up of the older, laterally agglutinated twigs. The youngest, terminal portions of the branches which, under the name of twigs, have been described in this paper as the immediate supporters of the colonies of monads, are evidently tubular. They appear to be as flexible as a spider's thread, and are usually quite irregular in outline, and in the calibre of the canal which permeates them. The wall of these tubular twigs is quite thick, and is alike rough on the exterior and interior faces. The substance within the tubes appears homogeneous, but whether it is solid or fluid could not be determined. The oldest part of the stems is of a reddish-brown colour; but as they taper off into branchlets they gradually assume a gamboge-colour, and finally terminate in scarcely coloured twigs.

Reproduction by fissigemmation is the only method of propagating individuals which I have observed. As a preliminary to this process the monad gradually loses its fusiform shape, assumes at first an oval contour, and finally becomes globular. During this transition, both of the prehensile cilia become much more conspicuous than usual, and the body developes a closely fitting hyaline envelope about it, thus passing into a sort of encysted state. The contractile vesicle, however, does not seem to cease its pulsations during this period, and moreover it becomes quite conspicuous. This arises mostly from the fact that the body is in a nearly quiet state, and allows the observer to obtain a prolonged and undisturbed view of it. Unfortunately the rate of the pulsations of this organ was not ascertained when the following observations were made, because the whole time was occupied in watching and drawing the various and rapidly changing phases of self-division.

After the body assumes a globular shape, as above mentioned,

both the larger and smaller cilium seems to be undergoing a change, and becomes indistinct in outline*. Presently two larger flagella burst upon the view, apparently by the longitudinal splitting of the previously single one of the same kind, and rapidly separate from each other by the broadening of the body, and leave between them the smaller cilium. The latter at this time appears much thicker than usual, and seems to be composed of two closely approximated parallel threads. By this time the contractile vesicle has also divided into two, which lie closely side by side.

At this moment the time noted in one series of observations was 2.30 P.M. By 2.35 P.M. the larger flagella had separated still further, and the smaller cilium had split into two very conspicuous filaments, as yet, however, attached to a common point of the body. From this time forth to the completion of the process of fissigemmation all of the cilia kept up a slow vibration, in which they undulated from base to tip with a sort of snake-like motion. By 2.45 P.M. the body had become quite appreciably broader than long, the contractile vesicles were widely separated, and the smaller cilia had left between them a considerable space, and each one had approximated quite near to the base of a larger flagellum. At 2.50 P.M. the body had become nearly twice as broad as long, and the space between the two pairs of cilia was nearly twice as great as in the last phase, and considerably depressed in the middle, so that the body had a broadly cordate outline. By 2.52 P.M. the posterior end of the body (at a point a little to one side of the spot where it was

* In a new freshwater genus (see note 2) of sedentary, monadiform Protozoa (possessing two contractile vesicles, and only the *sigmoid flagellum*, the latter arising within a deep bell-like flange or projecting rim which embraces the anterior end of the body) this arcuate filament disappears altogether, by a sort of withering down from tip to base, reminding one of the shrivelling of the end of a cotton thread in the flame of a lamp, preliminary to the commencement of the longitudinal fissigemmation of the body and its bell-like flange; and then the new flagellum of each resultant of self-division grows out in about twenty minutes.

[2] *Codosiga*: κώδων, a bell, σιγάω, to be silent. *C. pulcherrima*, n. sp. Body obliquely obovate, and tapering at its posterior end into a slender pedicel; truncate and abruptly constricted in front where the base of the bell meets the body. Sigmoid arcuate flagellum as long as the body and bell. The two contractile vesicles in the posterior third of the body; superficial, large, and quite conspicuous, each contracting, alternately with the other, once in about half a minute. Bodies attached, in groups of from two to eight, by their pedicels to the tip of a slender stem; erect or divergent, but not pendent. Mouth at the base of the flagellum, *i. e.* terminal. Anus near the mouth. No eye-spot. Bell slightly flaring; half again deeper than broad; fully as deep as the length of the body; highly contractile. Colour of the body (excepting the hyaline bell), pedicels, and stem deep yellow. Common on fresh-water weeds about Cambridge, U. S.

attached to the pedicel) was also slightly indented, so that in outline it presented a guitar-shaped figure, each rounded half of which bore a pair of unequal cilia, and contained a contractile vesicle. In one minute more the contraction had increased to such an extent that the body was divided about halfway through. By 2.54 P.M. the animal had a dumb-bell shape, and the pedicel was attached to one of the segments near the point of constriction. Still the process went on very rapidly, and by 2.55 P.M. the new bodies were widely separated, but still attached to each other by a mere thread. At 3 P.M. the body which was attached to the pedicel was left alone, and its companion swam away to seek a new attachment and build up its stem.

To the last moment the hyaline envelope remained about the segments, and in fact so long afterwards that time and circumstances did not allow me to ascertain its final disposition. I would remark, however, that when the ovate bodies of the half-grown monads are contracted temporarily into a globular shape, they appear identical (excepting that they lack the hyaline envelope) with these recently fissated forms. In all probability, therefore, the latter lose their envelope and assume the shape of the former.

As to the development of the stem, I think it quite certain that it grows out from the posterior end of the body. The best proof of this is, that I have frequently found a monad (especially in the condition of the one which I described above as breaking loose from its companion) nearly sessile upon a clean spot, and attached by a very short, faint, film-like thread. From this size upward I had no difficulty in finding abundant examples as gradually increasing in diameter as they did in length—thus furnishing a pretty strong evidence that the stem grows under the influence of its own innate powers, and is not, therefore, a deposit emanating from the body of the monad, except, perhaps, as far as it may be nourished by a fluid circulating within its hollow core.

LVI.—*On Two European* Argulidæ, *with Remarks on the Morphology of the* Argulidæ *and their Systematic Position, together with a Review of the Species of the Family at present known.* By T. THORELL.

[Concluded from p. 286.]

IV.

I SHALL now pass in review the species of Argulidæ hitherto known, although many of them are so incompletely described that it is not without difficulty that they can be determined.